2004 Fuel Cell Seminar, San Antonio, Texas

High Throughput Synthesis, Performance and Stability of Electrocatalysts for Hydrogen-Air Fuel Cells

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Technical Approach

High throughput catalyst synthesis

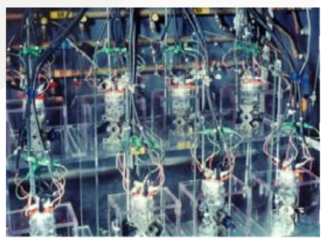
Catalyst screening

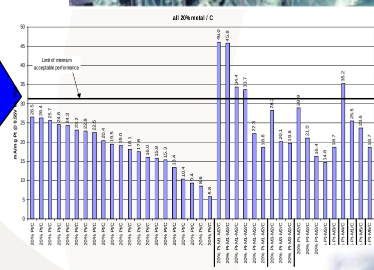
Select best candidates from primary screen

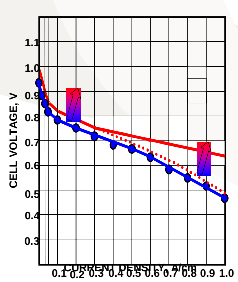
Produce at larger scale

MEA testing and optimization

100 mg







1000's kg

- **CSMP:** build a **high throughput powder synthesis platform** and use it for screening large variety of compositions for oxygen reduction electrocatalysts
- **DuPont Fuel Cells:** use rapid screening method for electrocatalysts and develop **rapid electrode fabrication method**
- **CSMP:** characterize structure, scale up best performing alloy electrocatalyst, test and optimize electrode structure in hydrogen-air MEAs
- **CFDRC:** modeling of the electrode structure
- **CSMP**: deliver electrocatalysts and test MEAs to stack manufacturers

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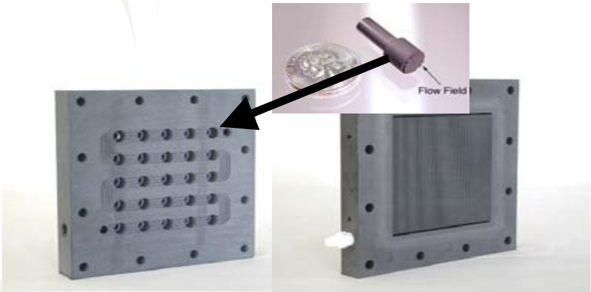
Summary of Accomplishments

- Unique high throughput platform for supported electrocatalyst in place (synthesis and screening)
- Focused approach in combination with structure characterization
- Initial targets for throughput met and potential for significant increase
- Shift from alloys benchmarking and optimization mode to a discovery mode
- Optimization of MEA structure led to a significant performance improvement
- Performance targets met in a single MEA
- Long term stability testing in progress

Current Work

- Execute detail plan on ternary alloy systems synthesis and testing
- Strong emphasis on long term stability of electrocatalysts and MEAs
  - Stability in acidic media
  - Stability to active phase agglomeration
  - Optimal MEA structure
- Testing in stacks
- Execute path forward identified for rapid MEA screening tool
- Rapid Testing in MEA configuration
  - Evaluate NuVant Systems Rapid Testing Device
    25 mini fuel cells, referenced against the same counter electrode



Comparison of Spray Pyrolysis *vs*. Conventional Catalyst Preparation Approach

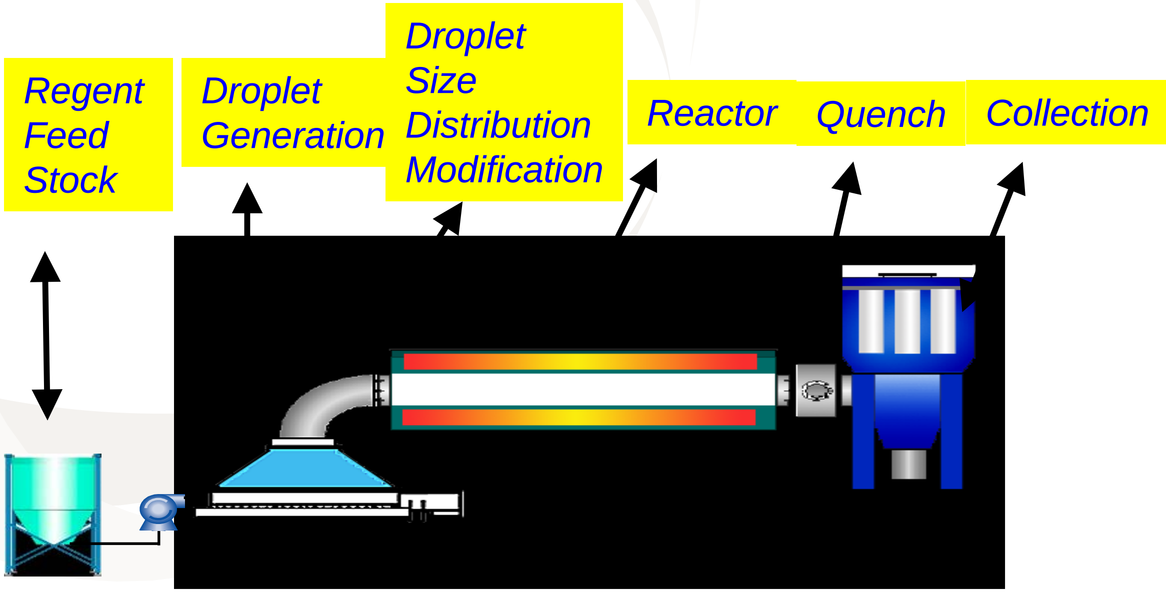
- **Spray pyrolysis**: reduced catalyst preparation steps for multi-component compositions.

Conventional Processing

- Disperse carbon black in water
- Stir 15 minutes
- Add sodium bicarbonate and stir for 5 minutes
- Heat to 100 C and boil for 30 minutes
- Dissolve H_2PtCl_6 in water
- Add to slurry over 5 minutes
- Boil for 5 minutes
- Dissolve $NiNO_3$ in water
- Add $NiNO_3$ solution over 10 minutes to slurry
- Boil for 2 hrs
- Make formaldehyde solution
- Add formaldehyde to slurry over 10 minutes
- Boil for 60 minutes
- Filter
- Wash with water
- Vacuum dry
- Heat to 930 C for 60 minutes in N_2

CSMP Spray Processing

- Dilute carbon colloid
- Dissolve Pt and other precursors and add to carbon suspension
- Pour into spray delivery system
- Spray and thermally decompose
- Remove product from collection housing bucket
- Post process in single step if necessary



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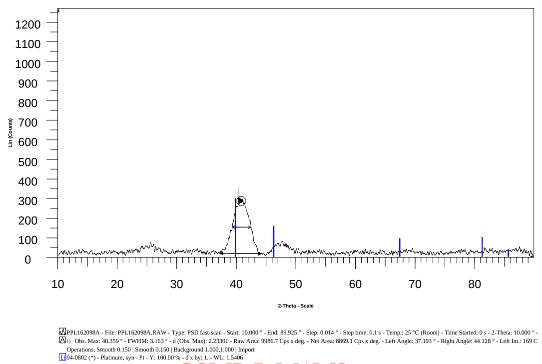
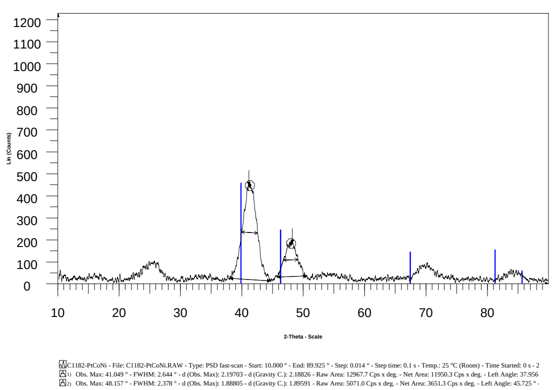
Comparison of Spray Pyrolysis *vs*. Conventional Catalyst Preparation Approach

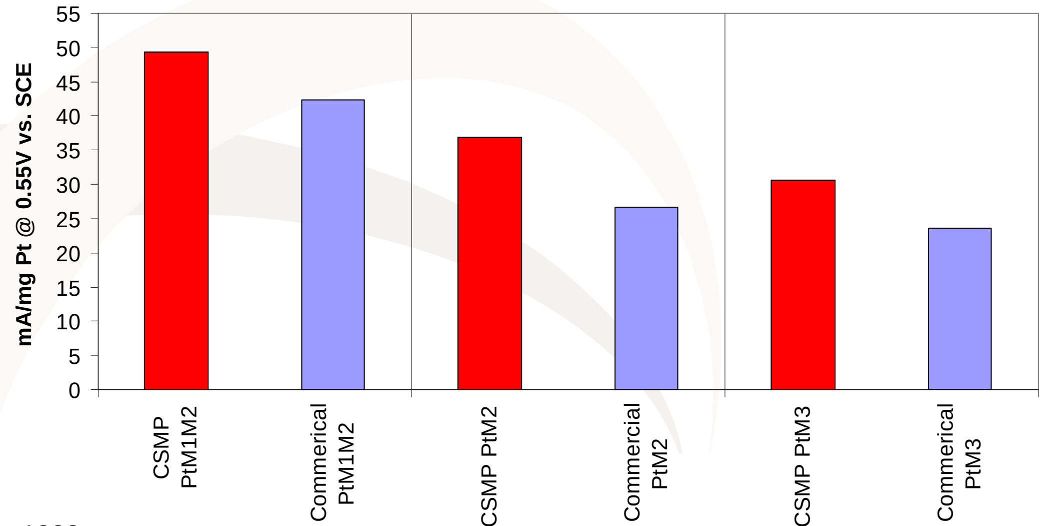
- Spray pyrolysis generates highly active alloy catalysts.

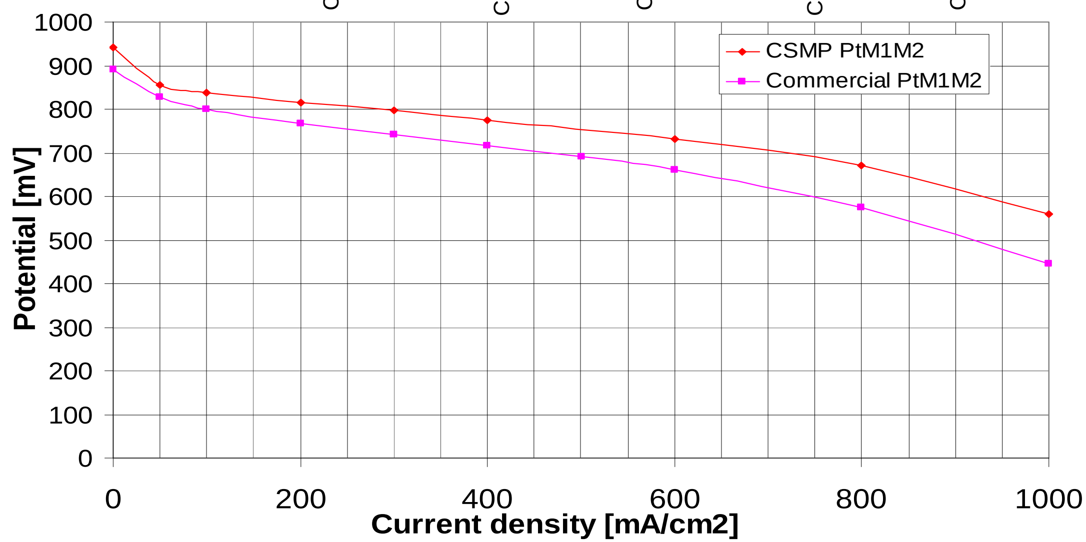


CSMP PtM1M2

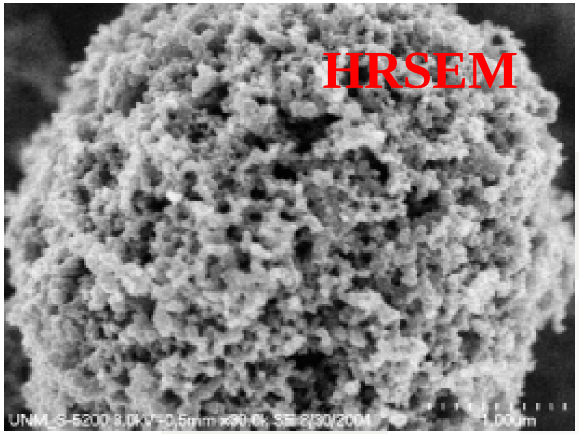


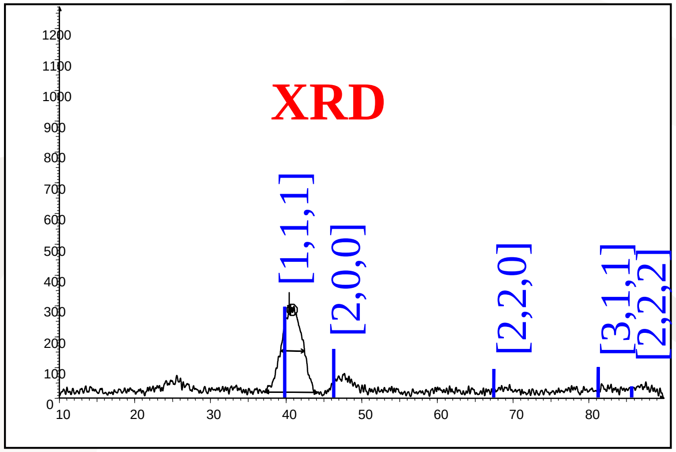
Commercial PtM1M2

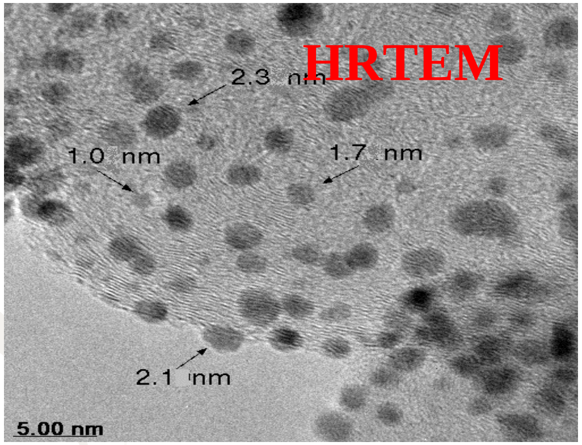


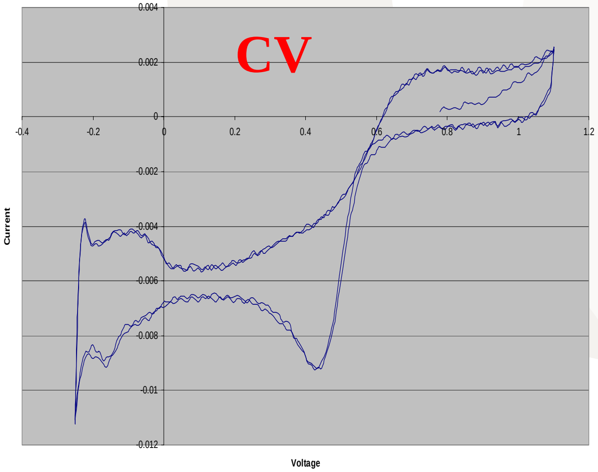


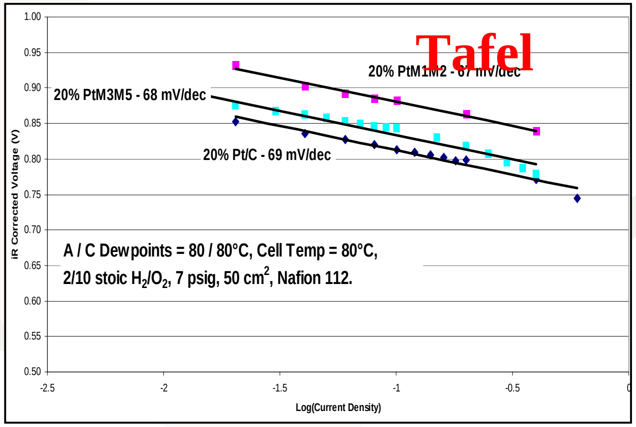
Structural and Electrochemical Characterization

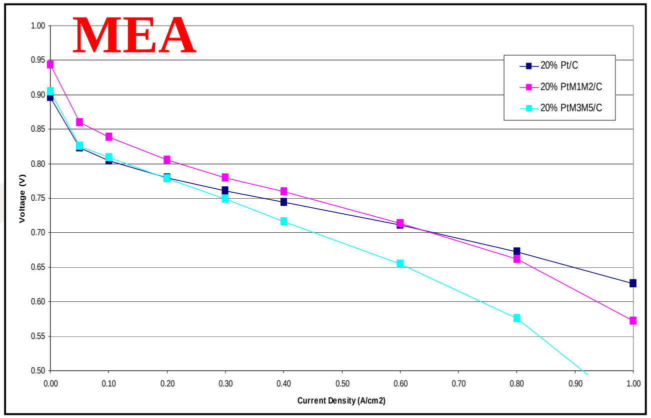






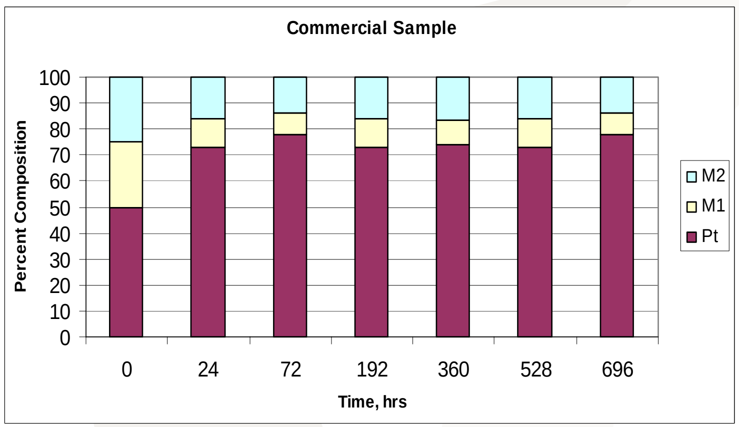


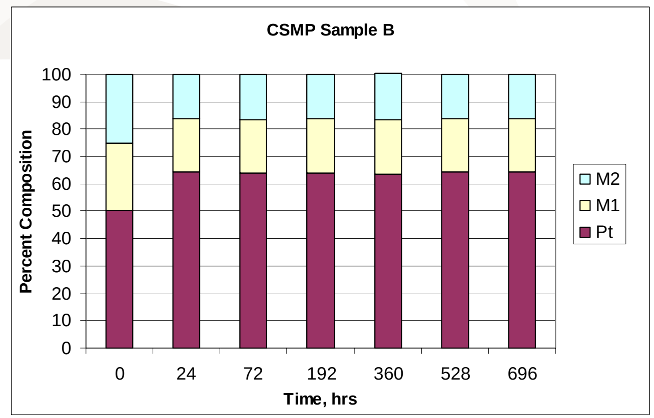


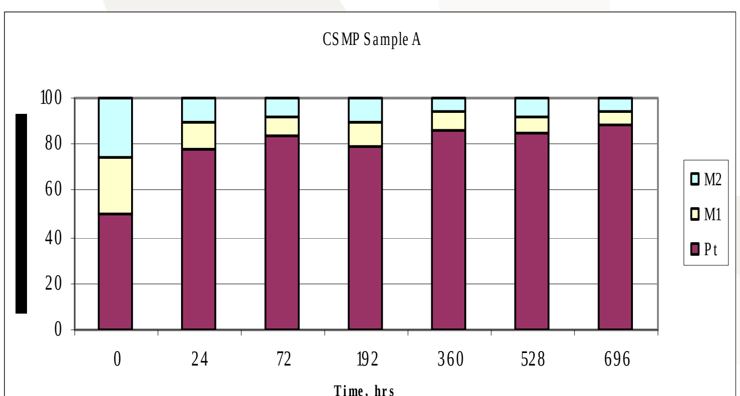


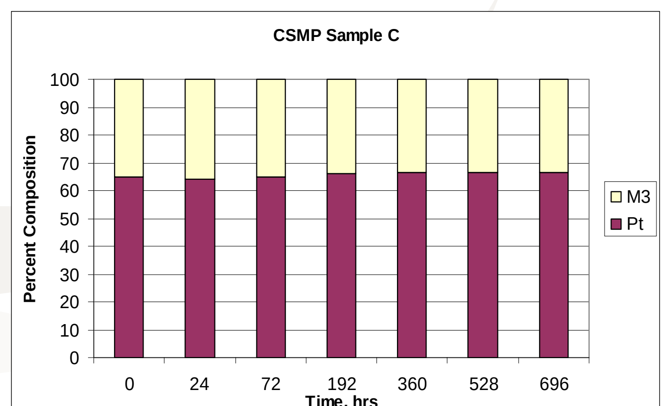
Leaching of Alloys

- Approach
  - Selected binary/ternary compositions were leached in acid at 85°C.
  - ICP analysis.



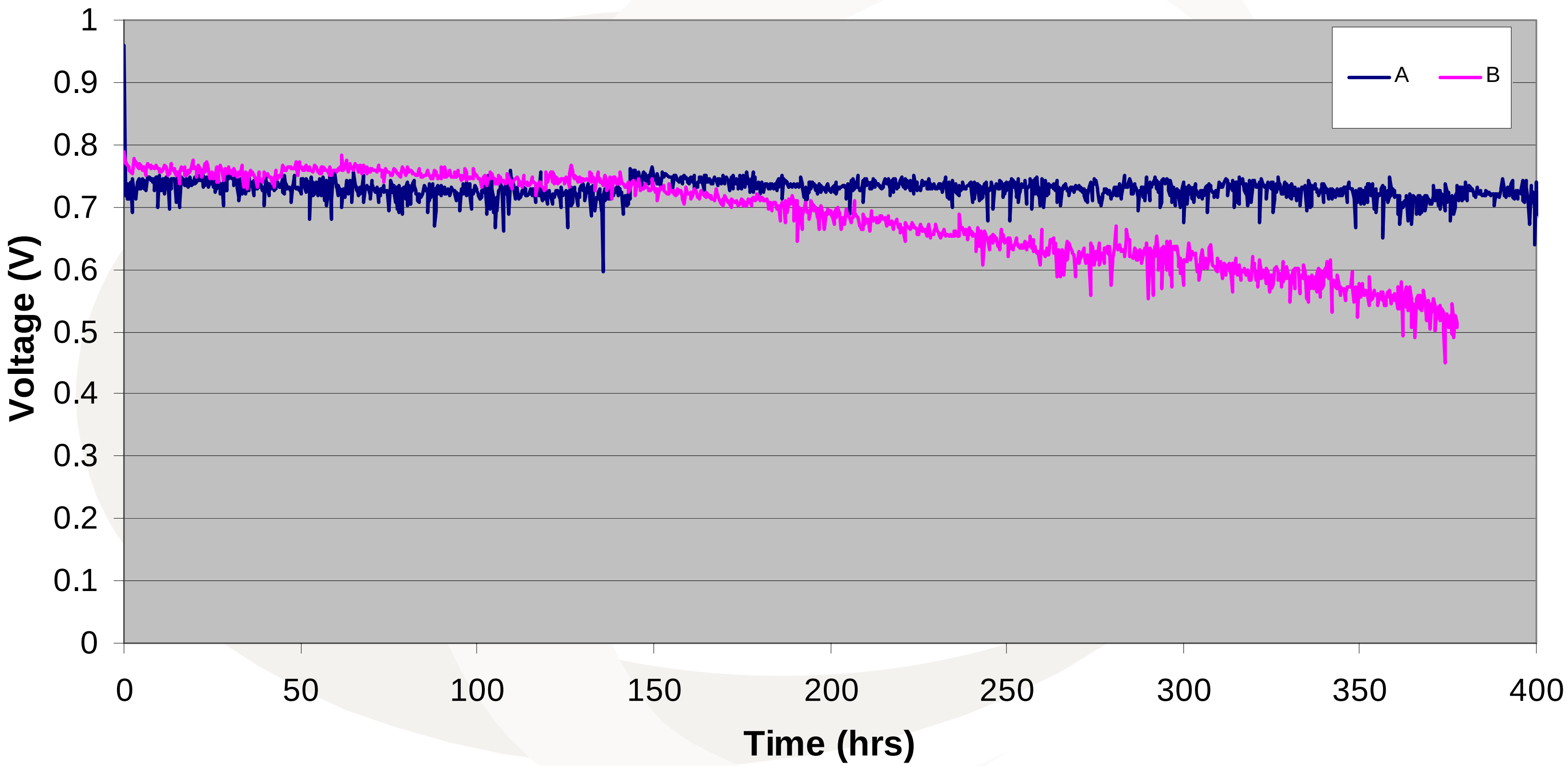






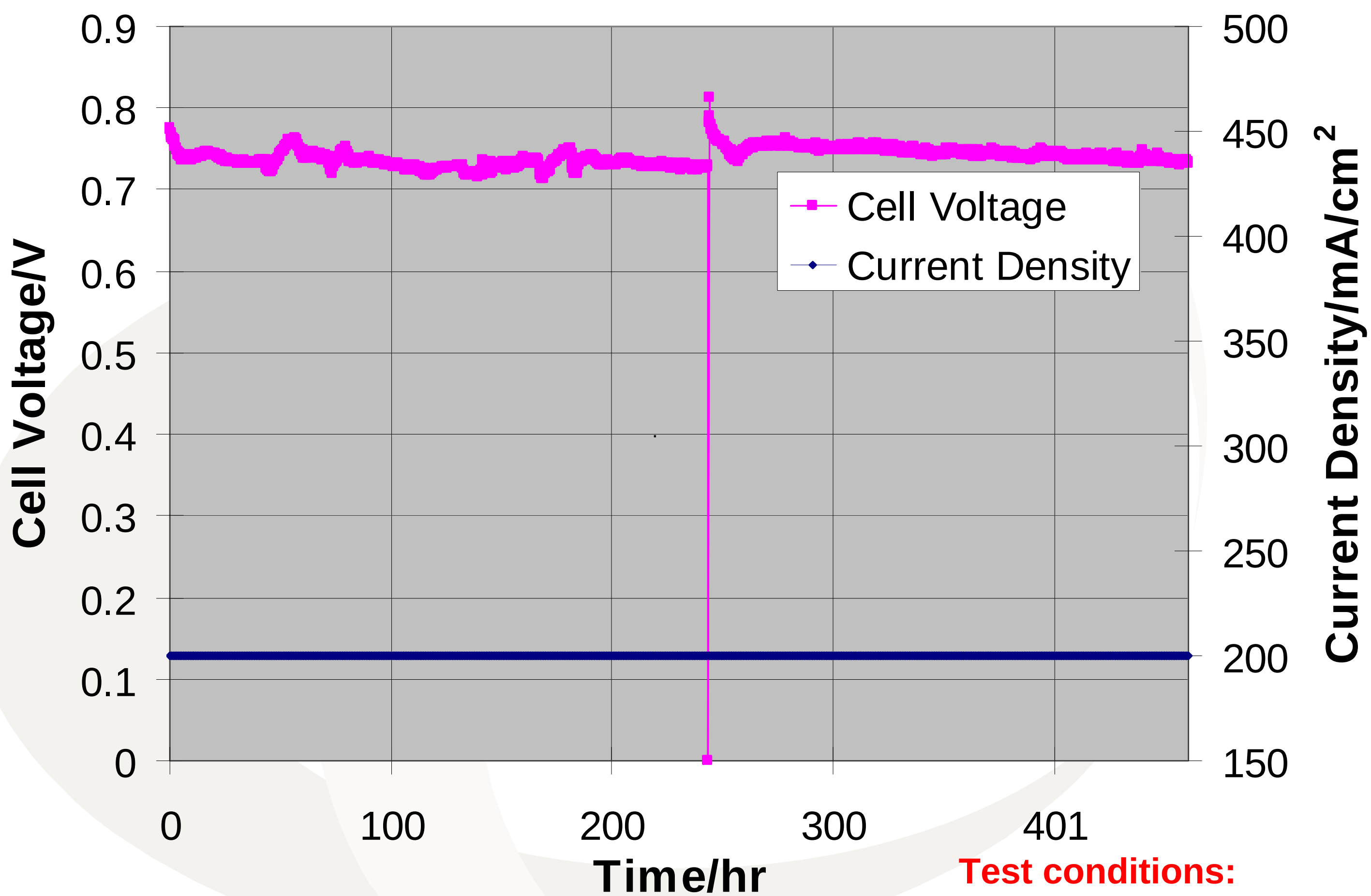
Long Term Stability

- Various Mechanisms – study of the long term stability of electrocatalysts under operating conditions requires stable MEA structure and simultaneous evaluation of all mechanisms of degradation: membrane, electrocatalyst, MEA structure



* Cathode: 50% Pt/C   * Anode: 10% Pt/C

Long Term Stability (*cont'd*)



Test conditions:

- Single MEA 50 cm^2 test cell, Nafion 112
- Cell temperature 80C
- 30 psig pressure on both anode and cathode
- 100% humidification of gases, 80C dew point

- Cathode: 20% Pt Alloy/C.
- Anode: 10% Pt/C.

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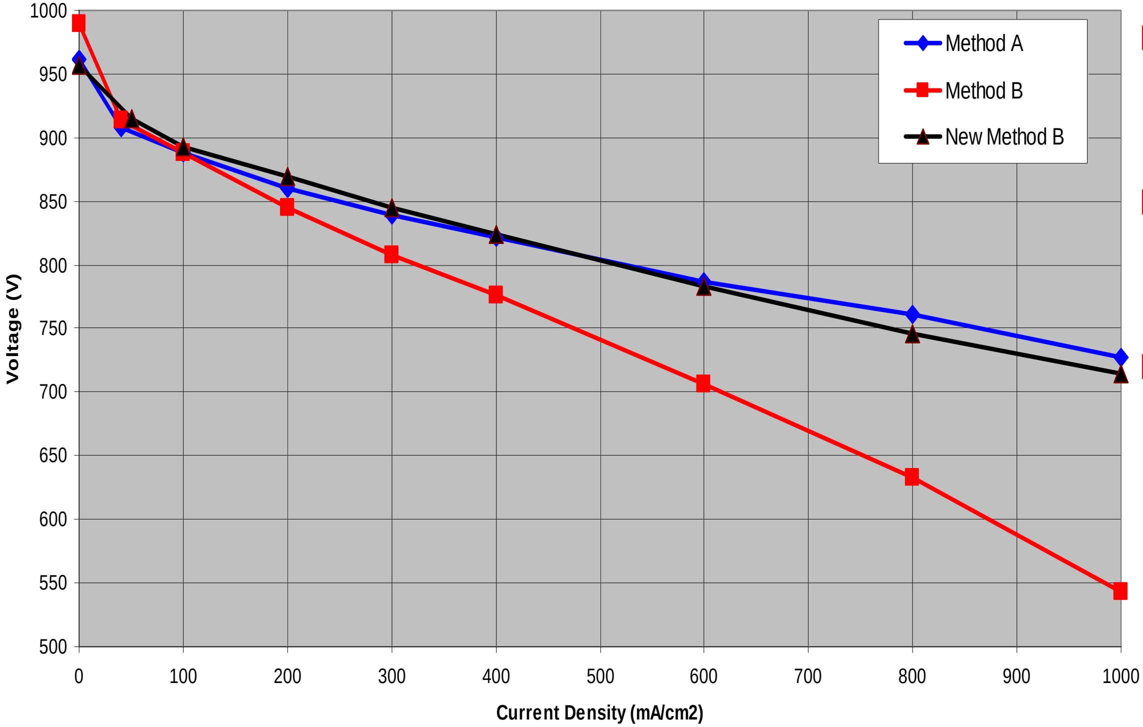
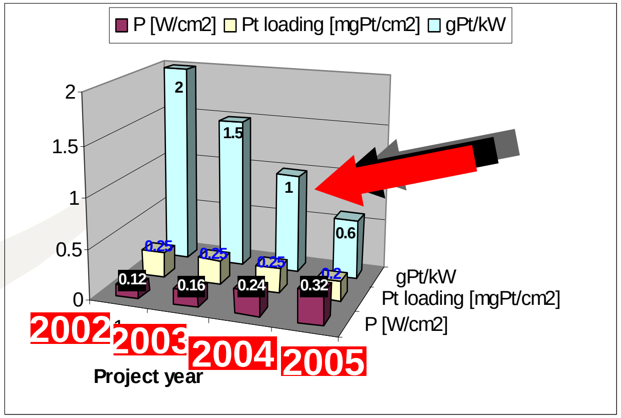
MEA Optimization



- Design of experiments involving 5 variables in MEA preparation performed
- The response variables were the single cell current densities at 0.8V and 0.7V.
- Goal: to maximize the value of the response function while maintaining the anode loading around its minimum value



- **Method A:** **1.5 gPt/kW** **Method B:** **2.6 gPt/kW**
- **0.55 mg Pt/cm^2 total loading, 50wt.%Pt/C, Nafion 112**
- **New Method B: 0.4 mg Pt/cm^{2}total loading**

  1 gPt/kW at 0.8 V; 0.7 gPt/kW at 0.75 V

  0.6 gPt/kW at 0.7 V

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- **CFDRC: Sandip Mazumder, Ashok Gidwani**

CSMP's New Facility in Albuquerque